TEMPLE UNIVERSITY
Department of Mathematics

Applied Mathematics and Scientific Computing Seminar

Room 617 Wachman Hall

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Multiphysics and Multiscale Modeling of Cardiac Dynamics

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Abstract.

The heart is a coupled electro-fluid-mechanical system. The contractions of the cardiac muscle are stimulated and coordinated by the electrophysiology of the heart; these contractions in turn affect the electrical function of the heart by altering the macroscopic conductivity of the tissue and by influencing stretch-activated transmembrane ion channels. In this talk, I will present mathematical models and adaptive numerical methods for describing cardiac mechanics, fluid dynamics, and electrophysiology, as well as applications of these models and methods to cardiac fluid-structure and electro-mechanical interaction. I will also describe novel models of cardiac electrophysiology that go beyond traditional macroscopic (tissue-scale) descriptions of cardiac electrical impulse propagation by explicitly incorporating details of the cellular microstructure into the model equations. Standard models of cardiac electrophysiology, such as the monodomain or bidomain equations, account for this cellular microstructure in only a homogenized or averaged sense, and we have demonstrated that such homogenized models yield incorrect results in certain pathophysiological parameter regimes. To obtain accurate model predictions in these parameter regimes without resorting to a fully cellular model, we have developed an adaptive multiscale model of cardiac conduction that locally deploys detailed cellular models only where needed, while employing the more efficient macroscale equations where those equations suffice.

Applications of these methods will be presented to simulating cardiac and cardiovascular dynamics in whole heart models, as well as in detailed models of cardiac valves and novel models of aortic dissection. Necessary physiological details will be introduced as needed.